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JOURNAL

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THE ROYAL ASIATIC SOCIETY.

ART. I.—*Summary of the Geology of Southern India.* *By* CAPTAIN NEWBOLD, F.R.S., &c. *Assistant Commissioner for Kurnool.*

[*Continued from* vol. viii., p. 270.]

PART IX.—PLUTONIC ROCKS.

GRANITE.

Geographical Extent.—Granite prevails throughout the great hypogene tracts, the limits of which have been already defined, sometimes rising abruptly from the surface of immense level plains, in precipitous, peaked, and dome-shaped masses; sometimes in low slopes; sometimes in great heaps of amorphous masses; at others with sharp outlines, obscured and softened down by a mantle of the hypogene schists which have accompanied its elevation. This latter occurs most frequently in continuous mountain chains, such as the Ghauts; but to view this rock in all the boldness of its true physical contour, we must approach the detached ranges, clusters, and insulated masses that break the monotony of the table-lands of India. Here we find but little regularity in the direction of elevation. In many clusters, of which I have taken ground plans, the granite appears to have burst through the crystalline schists in lines irregularly radiating from a centre, or in rings resembling the denticulated periphery of a crater.

The most remarkable of the insulated clusters and masses of granite on the table-land of the peninsula are those of Sivagunga, Severndroog, Ootradroog, Nundidroog, Chundragooty, and Chitteldroog, in Mysore; Gooty, Raidroog, Adoni, Bejanugger, Gongondla, in the Ceded Districts; and those of Hydrabad, Paungul, Annagoondy, Copaldroog, and Idghir. In the country south of the Salem break, are those of Trichinopoly, Dindigul, and Alighirry; and in the maritime tracts of the Coromandel, are those of Vellore, Arcot, and Permacoil. The islands in the Chilka Lake, at the northern extremity of our area on the east coast, are of porphyritic granite

Geological Features.—The rock of Nundidroog is almost one solid monolithic mass of granite, rising 1700 feet above the plain, and upwards of 4700 feet above the sea; that of Sivagunga is still higher.

These masses have usually one or more of their sides precipitous, or at such an angle as to be inaccessible except at a few points. This circumstance, added to that of their insulated uncommanded position, has led to their being selected by the natives for the sites of some of their *droogs* and strongest fortresses. Many of the names I have recapitulated will serve to remind the historical reader of the bloody struggles these granite masses have been silent witnesses of. Most of them, like that of Severndroog, are so steep as to admit of little vegetation, and present surfaces of many thousand square feet of perfectly naked rock, in which the veins and mineralogical structure are beautifully laid bare to the eye of the geologist.

It is not to be understood that granite is only to be met with in Southern India in this abrupt amorphous form. On the contrary, it is sometimes found in immense undulating layers like lava rising little above the general level of the country, separated by fissures and joints, and running for a considerable distance in a given direction, like a regular chain of hills. The horizontal fissures often impart a pseudo-stratified appearance; and, when crossed by others nearly vertical, give the whole the semblance of some huge wall of Cyclopean masonry.

The cuboidal masses composing these walls weather by a process of concentric exfoliation into spheroids. This process occurs often on a grand scale, and the exfoliated portions compose segments of circles of many yards radii. This decay of lofty granitic masses produces some of the most picturesque features of an Indian landscape; its strange columnar piles, trees, and logging stones, which far excel those of Dartmoor in grandeur, and in the fantastic forms they assume.

I have attempted to describe the *modus operandi* of this spontaneous exfoliation in a previous paper on the Granites of India and Egypt[1]. Suffice it now to observe, that I consider it to be the result chiefly of meteorological and electric causes, acting upon and developing a latent concentric structure in the granite totally independent of any supposed planes of stratification, and resembling that often observed in basalt and lava. It is observed also in those stratified rocks which have been most heated, and altered by granite,—such as gneiss. The vertical laminæ of stratification, and even individual imbedded crystals of felspar, are seen crossed at right angles to their direction and planes of cleavage by these lines of exfoliation. This concentric structure appears to be an approach to crystallization on the large scale originally induced by heat. The nuclei usually exhibit a tendency to the oval, globular, or dodecahedral form, and may be regarded as crystalloids. Sometimes the structure is obscurely prismatic.

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[1] Journal, Vol. VII., p. 114.

At Boyagudda, in the Ceded Districts, a cluster of granite rocks occurs, in which one of those great natural walls, caused by the process of disintegration first alluded to, is seen:—a large rhomboidal mass, of many tons weight, has fallen out of the centre of this wall, leaving against the horizon the singular appearance of a large window. These walls will always be found where the circumference of the exfoliating segments is large, and the surface on which they rest consequently less inclined than where the circles are smaller. From the latter the exfoliating masses slide off to the base, leaving, perhaps, a columnar pile of cuboidal or spheroidal blocks on the summit or most horizontal part of the subjacent boss. Some of these piles are held together in the most extraordinary positions: and the blocks composing them are found connected by a felspathic, siliceous, and ferruginous paste, the result of the decay of the upper masses, washed down and deposited around the joints by the action of the rain. There they stand; some tottering on their base, leaning over, and threatening every instant to topple down upon the unwary traveller; others erect, amid a ruin of debris at their feet,—silent monuments of the process of the surrounding decay. Sometimes the summits of the higher elevations are composed of immense monolith peaked masses of granite, which split vertically; the separated portions are often known to descend from their lofty position with the rapidity and thunder of an avalanche. The different shades of colour observable on the same mass of rock, which have puzzled some observers, arise from exfoliation. If the exfoliation is recent, the surface will be found whitish or grey,—the natural colour of the granite; and if of a remote date, the surface will be darker and more or less weathered: the exfoliation of the iron contained in the mica and hornblende imparting to it a rusty appearance, darker in proportion to the quantity of iron. This dark colour is often increased to blackness where rain water lodges or runs over the surface; in some situations the colouring matter forms a thin coating from 0·1 to 0·4 of a line thick, composed principally of carbon, carburetted iron, oxide of iron, and occasionally manganese, with silex and alumina; the carbon has been superadded by the rain water; the rest of the components by the rock itself. A similar coating is observed on the granite in the beds of rivers; Humboldt noticed it among the cataracts and falls of the Orinoko. This phenomenon is said to be confined to intra-tropical countries.

The disintegration of the surface of granite, when not exposed to the action of water, lime, or carbonic acid gas, is, in general, remarkably slow. The outside of the oldest Hindu pagodas, built of great blocks of this rock, rarely exhibit a decay reaching more than the eighth of a line; the surface of the granite quarries of Syene, cut probably before Abraham, and those of Bijanugger, whence were hewn the large blocks seen in the ruins of that great Hindu city, built upwards of five centuries back, are nearly as fresh as if split yesterday, and the marks of the chisel appear quite sharp and plain.

M. Becquerel has noticed this slow decay of granite in Europe. The exterior of the cathedral of Limoges, which was built about four centuries ago, exhibits a disintegration of about 8 millimetres on the average; while that of the granite in the quarry whence the stones were cut, shows one amounting to 1^{m} 62. M. Becquerel, supposing that the progress of the alteration in the mass of granite took place in the ratio of the time, thinks that the alteration must have commenced about 82,000 years ago. In making this calculation, M. Becquerel does not appear to have taken into consideration that the granite in the quarry is liable to the intrusion of carbonic acid gas, the infiltration of water charged with carbonate of lime, moisture, and electric causes which either do not operate at all, or in a less ratio, on the stones of which the cathedral are built; and that the comparatively polished surface of the latter greatly contributes to preserve them from disintegration.

I shall have occasion to advert to the extensive decay of granite under the surface of the soil by the action of water charged with carbonate of lime.

As the rocks waste from the summit, at their base will be usually observed a tendency to a re-arrangement of the component particles of the rock going on in the debris there accumulated. At Chittledroog I found at the base of a granite cliff which topped one of the hills, a porphyritic-looking mass thus formed, of a reddish clayey paste, imbedding reddish crystals of felspar.

Lithologic Character.—Almost every variety of this rock is found in Southern India. Brongniart has described granite as composed of lamellar felspar, quartz, and mica, nearly equally disseminated: but neither his nor McCulloch's more minute classification will comprehend the numberless lithologic differences to be observed often in the same mass. In one part we shall find the granite of Brongniart, as just described; in another, the syenite of McCulloch; in another, nothing but felspar and mica, quartz and hornblende, or felspar and hornblende; but the prevailing granite is composed of felspar, quartz, mica, and hornblende. Quartz, felspar, and hornblende, the syenite of some mineralogists, is also common, and runs into the ordinary granite. The syenite defined by Brongniart, as essentially composed of lamellar felspar, hornblende, and quartz, the felspar often predominating, is seen almost everywhere in granite districts. A good example occurs in the rocks of Paliconda and Tripatoor in the Carnatic, and on the east flank of the Eastern Ghauts, between Poornarvella and Cumbum. Benza[1] has supposed the Paliconda syenite to be of posterior origin to the usual granite of India, simply from its lithologic character, and from its being associated with trap, eurite, and porphyry. But the ordinary granite in its vicinity, into which it passes, is equally associated with these rocks. I am convinced that the geognostic distinction between granite and syenite will be found, as far as peninsular India is concerned, to exist in theory only, and that the terms we see so often abused, of syenite and syenitic granite, may be safely excluded, except for the sake of petrographical distinction, from the nomenclature of its rocks. Lyell[2] has well observed that some have imagined that the age of different granites might, to a great extent, be determined by their mineral characters alone; syenite, for instance, or granite with hornblende, being more modern than common or micaceous granite. But modern investigations have proved these generalizations to have been premature. The syenitic granite of Norway may be of the same age as the Silurian strata, which it traverses and alters; or may belong to the old red sandstone period; whereas the granite of Dartmoor, although consisting of mica, quartz, and felspar, is newer than the coal.

The term syenite appears to have been introduced by Werner, and applied by him to the Dresden rock, solely from his supposing it to contain the same minerals as the granite of Syene in Upper Egypt. Now the granite of Syene, which I have carefully examined, is quaternary granite, being composed of a crystallized flesh or rose-coloured felspar, quartz, mica, and hornblende. Humboldt was the first to point out the mistake of Werner, as to the geological position of the Dresden rock, which he supposed to be the same as that of Egypt.

That beautiful variety of granite, called protogine by French geologists, in which talc, or chlorite, or steatite replaces the mica, and which abounds in the Alps and in some parts of Cornwall, is not very common in India. I have met with it at Sautghur in the Carnatic, Mustoor on the south bank of the Kistnah, and in a few localities in Mysore, Salem, the Ceded Districts, and in the Nizam's territories. In all these cases chlorite and talc were the replacing minerals; the former predominating. Pegmotite, granite composed of quartz and felspar, is frequently met with; but the variety called graphic granite is rare. I have seen it only in the vicinity of Paungul, Nizam's territories, at Poddioor, the beryl locality, in Coimbatore, and in a few other localities, in veins penetrating gneiss.

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[1] Madras Journal, Vol. IV., p. 18.

[2] Elements, Vol. II., pp. 351 and 352. Second Edition.

Schist granite never occurs as a mountain mass, but is found in veins or patches imbedded in ordinary granite. The same may be said of actinolitic granite, or granite in which actinolite replaces mica. The latter usually is most frequent in hornblendic granite, and the actynolite passes by insensible gradations into hornblende. The felspar of actinolitic granite is usually flesh or salmon-coloured.

Orbicular granite, for which Corsica is celebrated, has not hitherto been discovered in Southern India.

Colophonitic and Garnetiferous Granite.—Colophonitic and garnetiferous granite occurs in the Nilgherries; the latter is pretty generally distributed, particularly in the Nellore and Salem districts, and on the skirts of the Eastern Ghauts northerly towards Orissa.

Porphyritic Granite.—Porphyritic granite, or granite having large crystals of felspar imbedded in ordinary, or small-grained granite, is common. The rock of Severndroog in Mysore affords a good example of the prevailing variety. It is composed of a granite base of felspar, quartz, mica, and hornblende, imbedding long pale rose-coloured crystals of felspar.

Granite Porphyry.—Fine granite porphyries are less frequently met with: a beautiful specimen occurs in a large vein or dyke which traverses the gneiss in the bed of the Cauvery at Seringapatam, nearly opposite the Sallyport, close to which Tippoo was killed. It is composed of a basis of compact reddish and salmon-coloured felspar, and a little quartz, imbedding lighter coloured crystals of the same, with needle-shaped crystals of green tourmaline.

Granite in which albite replaces the ordinary felspar occurs in the Eastern Ghauts north of the Kistnah, at Poddioor in Coimbatore, and occasionally in other localities.

The great prevalent mineralogical feature in the granite of Southern India, which, and the absence of tin ore, so strikingly distinguishes it from the granite of the Malayan peninsula on the opposite side of the Bay of Bengal, is its highly ferriferous nature. The mica and hornblende is frequently replaced by magnetic iron ore in grains, veins, and beds; and sometimes, as in the Salem district, by fine octohedral crystals of the same, with polarity.

Most of the minerals and ores described as occurring in gneiss are also found in granite.

Beautiful crystals of amethystine quartz are found in the immediate vicinity of Hydrabad and Shumsabad, and occasionally kyanite. Fluor spar, sphene, lapis lazuli, anthophyllite, and stilbite, have not hitherto been found in the granites of Southern India.

Veins and Nests in Granite.—The ordinary granite of India is traversed by veins of granites both finer and larger grained: the former pass into eurite, a rock in which all the component minerals of granite are mingled together in one almost homogeneous paste.

The minerals composing the larger grained veins, are often in a state of segregation and crystallization. The mica, instead of being scattered in minute scales throughout the substance of the rock, is sometimes collected in large plates nearly a foot in length (used by natives for painting on); the quartz in large amorphous nodules, or hexahedral pyramidal prisms of equal length; and the felspar by itself in reddish layers and beds. The same tendency to segregation takes place also in great continuous masses of granite, and seems to depend on causes which will be described in speaking of the proneness to compactness and crystallization observable on the edges and in the centre of trap dykes: for, as far as my observation goes, the greatest tendency to segregation and crystallization in the different minerals composing granite will be found to recur most frequently towards the centre of areas occupied by granite, and *vice versâ*, near the edges; but this is not invariably the case. Sometimes we see crystals of mica and felspar shooting their long *axes* in a parallel direction over granite tracts of considerable extent, and at others confusedly huddled together. The last arrangement is by far the most prevalent. The causes of this apparent common polarity of the crystals in one situation and their irregularity in another have never been satisfactorily explained, and are a subject of interesting research.

The veins and beds of felspar are usually reddish, and penetrated by fissures, which give a prismatic structure: these fissures are often lined with compact felspar, coloured by actinolite, or chlorite, or with drusy crystals of the former mineral, which is also found in nests. Milky quartz is segregated into large beds forming chains of hills, usually containing nests and seams of iron ore, rock crystal, and crystals of amethystine quartz. Both oval and lenticular nests of hornblende and mica occur in granite, which have been mistaken by some for imbedded rounded pebbles from the hypogene schists; but they are the result, evidently, of the process of mineral segregation just alluded to.

Veins of Granite in other Rocks.—Granite is seen in veins penetrating the hypogene schists of Southern India. Good examples occur in the Darogi hills, near Bellary, near Hydrabad, and Seringapatam.

The rock of Sanklydroog, in the Salem districts, a large mass of gneiss, is completely broken up by veins of a porphyritic granite, which has burst from below; the gneiss and associated layers of a fawn-coloured crystalline limestone exhibit evident marks of alteration, and are dotted with garnets; the limestone effervesces but feebly with acids. The porphyritic granite here in some situations loses its mica and quartz, and passes into a granite porphyry, composed of a paste of compact reddish felspar, imbedding crystals of the same of a flesh-red colour. The whole mass of rock, which is almost bare of earth and vegetation, forcibly brought to mind McCulloch's sketch of the granite veins penetrating the gneiss at Cape Wrath.

Intrusion of Granite in a solid form.—Granite, though occasionally found in veins, appears in many situations to have broken through the earth's crust in a solid form; as is evident from the sometimes unaltered and shattered condition of the strata immediately in contact. Where the granite breaks through the sandstone, between Gooty and Kyelcherroo in the Ceded Districts, the latter has been fractured so much as to form a breccia near the contact line. No granite veins are to be seen in the sandstone; the latter rock, however, in other situations has evidently been altered by the granite.

Before quitting the subject, I shall briefly notice a feature in the granite of Southern India which seems to have escaped attention, viz., that of its occurring sometimes in alternating hard and soft layers like lava or basalt, with wackes, clays, and amygdaloids; the softer layers of the granite differ merely in being of a granite more loosely aggregated, and often more micaceous and larger grained. The unequal weathering of these beds much influences the physical outline of granite tracts: when the layers are vertical, or nearly so, the softest layers disappear by weathering; their place being occupied by valleys or intervals separating the more compact layers; when the layers appear more horizontally above the surface, the outline of their edges presents alternate slopes and scarps; the termination of the harder layers forming the scarps. The effects of the process of weathering will be more fully entered into in describing the overlying trap. The great inclination of some of these granite layers proves them to have been disturbed since solidification.

Eurite.—The prevailing eurite of Southern India should be rather classed with the hypogene than the granitic series; although, in a few cases, as at Paliconda in the Carnatic, it is seen associated with granite. D'Aubuisson defines this rock as an extremely fine-grained granite in which felspar (compact) predominates; the whole forming an apparently homogeneous rock. The remarks of Sir H. De la Beche touching the European varieties are generally applicable to the Indian eurites, where similar discrepancies exist in the accounts of authors regarding this rock, the petrosilex of some, and the compact felspar of others. "Upon the whole," says Sir H. De la Beche, "we can scarcely avoid agreeing with M. Beudant, that, although there are certainly varieties of compact felspar, many substances, which cannot be considered as felspars, are so called often because it is not known what else to do with them."

Eurite is found throughout the granite and hypogene tracts of Southern India, but more frequently among the latter rocks, with which it often has all the appearance of being interstratified; in the granite it occurs in dykes. The eurite of Paliconda affords a good example of the compact felspar variety; while that associated with the gneiss, in the ditch of the fortress of Seringapatam, may be regarded as a type of the petrosilex eurites. It sometimes passes into eurite porphyry, imbedding distinct crystals of laminar felspar.

DIALLAGE.

Diallage rock, the euphotide of the French, and gabbro of the Italians, has been classed by Lyell with volcanic rocks, basalt, clinkstone, trachytes, hypersthenic rocks, greenstone, ophiolite, &c. I have only observed it in two localities in Southern India, viz., in the Salem district, and in Mysore, at Bannawara, about eight miles westerly from Bangalore; in both localities it is associated with gneiss and mica schist. At Bannawara it presents itself in low elevations, consisting of angular rough masses of the diallage rock, half buried in a detritus, the result of its own disintegration. The masses have not the slightest appearance of stratification; but are divided by fissures, like granite, into cuboidal blocks. McCulloch, who had an opportunity of observing this singular rock in Shetland, where it forms an extensive track, is of opinion that diallage is a stratified rock of the primary class[1]. It occurs there, indifferently, in company with gneiss, mica schist, chlorite schist, and argillaceous schist. He describes it as being intersected by innumerable joints, which break the rock, as at Bannawara, in an irregular angular manner, so as to confound all appearance of stratification. McCulloch concluded its being a stratified rock, from its alternation on the large scale with the primary schists just mentioned; its passing into talcose and chlorite schists; its frequently containing minute beds of micaceous, chlorite, and talcose schists; and more rarely, of hornblende and actinolite schists. It includes small masses of serpentine, and associates with large masses of the same rock.

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[1] Classification, p. 645.

The diallage of Bannawara, lithologically, assimilates that of the Shetlands. Its internal structure is granular crystalline; it breaks like granite in any direction, and is tough and difficult of fracture; its texture, however, never resembles the laminar structure of gneiss. The rock is composed chiefly of diallage and felspar; the colours of the former varying from light and dark grey to greyish green, and bright green. The felspar is white, and greyish white; sometimes in distinct crystals, but generally confusedly aggregated; the general colour of the rock is light grey and greenish grey.

The diallage at Bannawara has more the appearance of a dyke or vein in the hypogene strata, than of an interstratified bed; but no natural section of the junction line of the two rocks presents itself. This locality and its vicinity should be examined carefully, in order to ascertain the interesting question of the relation of the diallage with the stratified rocks.

I have little doubt that, as observation progresses, many other sites of this curious rock will be found in Southern India, as it occurs, as Mc Culloch observes, in very thin beds, and probably very widely separated from any other masses of the same substance: hence it has doubtless often escaped notice.

Serpentine.—Serpentines, and dark massive magnesian, and talcose rocks, analagous to serpentine in geological character, occur as dykes and thick beds in the hypogene schists of Salem. At Cottah Mungalagherry, near Bezwarah on the Kistnah, Captain Macpherson describes an elevated and indistinctly stratified mass of this rock as occurring in the coarse and thickly fissile argillaceous schist associated with the gneiss.

At Turivicary in Mysore I observed a dark crystalline rock, the massive and apparently unstratified character of which, the angular and spheroidal blocks which crested and covered the sides of its dyke-like elevations, and the rusty surface of some of their weathered fragments, deceived me at first sight into the supposition of its being one of those numerous outbursts of basaltic greenstone so common in that part of India, rising like a wall from the gneiss, mica, and talcose schists at its base. On close examination I found it was very different from any greenstone, or hornblende rock. It is composed of a dark grey or black talcose paste, imbedding numerous small black crystals of a mineral containing a large proportion of iron, being strongly attracted by the magnet. These crystals do not yield to the knife, and they fuse into a black slag. The paste usually yields to the knife, and is of various degrees of hardness in different specimens, and infusible, *per se*, before the blow-pipe. The fracture of the rock, on the large scale, is flat conchoidal; it is difficultly frangible.

It bears a beautiful polish; the surface exhibiting, on close inspection, in the dark shining paste, still darker spots occasioned by the magnetic crystals. It is quarried by the sovereigns of Mysore for architectural purposes, and forms the material of the beautiful pillars which support the mausoleum of Hyder at Seringapatam. This rock has been mistaken for basaltic greenstone by Buchanan, Benza and Malcolmson[1]. Buchanan and Benza took the dark magnetic crystals for those of basaltine or augite. The mistake is hardly surprising from the deceptive appearance of the rock, which does not seem to have been examined *in sitû*. To me, from its mineralogical and geological features, the idea suggested itself of its being a bed of massive ferriferous potstone here common in the talc schist, elevated, indurated, and altered by one of the basaltic dykes that traverse the rocks in the vicinity. A fragment, which I showed to Mr. Lonsdale, at the rooms of the Geological Society of England, was pronounced by him to be talcose rock. The variety of talc rock called potstone, the talc ollaire of Haüy, and the serpentine ollaire of Brongniart, not only mineralogically resembles serpentine, being composed principally of magnesia and silica, but is often associated with and passes into it. In Southern India I know of no locality where serpentine is found in large beds except in talcose areas.

Mr. Lyell[2] classes serpentine both among volcanic rocks and in the hypogene strata: in the former it is described as a greenish rock, in which there is much magnesia, usually containing diallage, which is nearly allied to the simple mineral called serpentine. It occurs sometimes, though rarely, in dykes, altering the continuous strata. In the hypogene series it occurs both as a stratified and unstratified rock; and, besides the minerals above mentioned, contains talc. McCulloch[3], in the latter part of his classification, after his examination of this rock in Shetland, was compelled to remove it from the division of unstratified rocks, in which he had first classed it, and place it among the primary or hypogene strata, after limestone. He remarks, however, on the indistinctness of the stratification in serpentine rocks, which he assimilates to similar features observable in primary limestones.

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[1] Madras Journal, Vol. IV., pp. 14 and 199.
[2] Elements, Vol. II., pp. 208 and 386.
[3] Classification, p. 652.

The serpentines of Southern India I should also be inclined to refer to the hypogene series, from their passing into these rocks, their causing slight or no signs of alteration, and from their never having been observed to project veins or dykes into the strata in contact.

Geologically viewed, the rock of Turivicary has all the characters of a serpentine; and, mineralogically, it resembles the ferriferous serpentine or ophiolite of Brongniart, which consists of a magnesian paste, imbedding disseminated grains of oxidulated iron.

The Salem beds are interstratified with talcose and hornblende schists, into which they pass, assuming the character of an ophiolite near the junction with the latter. The former line is blended with the serpentine, assumes a light-green hue, mottled with reddish, blackish, and dark-green spots. Chromate of iron, magnesite, asbestus, and nephrite, as in the hypogene and associated serpentines of Styria, Moravia, Turin, and Baltimore, occur in veins and nests.

In the Cuddapah diamond sandstone and limestone area, wherever a trap dyke penetrates the limestone, the latter will be often found at the contact line converted into serpentine.

BASALTIC GREENSTONE.

Geographical Limits.—Basaltic greenstone is universally distributed over Southern India; it prevails in hypogene areas; diminishes in those occupied by the diamond sandstone and limestone; and totally disappears in districts covered by laterite and deposits of a more recent epoch. It is most developed in the stretch of table-land between Bangalore and Bellary, in the Salem and Nellore mining districts, and in the Western Ghauts.

Geognostic Position and Character.—It never occurs in continuous overlying sheets like the newer trap, but penetrates in dykes the rocks just described up to the age of the laterite. These dykes often terminate on reaching the surface of the rock (fig. 1); or before reaching it (fig. 2); while others project from the surface in long black ridges (fig. 3); which, originally like a wall, have since tumbled into both globular and angular fragments, by that species of disintegration already described in speaking of the granite. Most of the blocks usually remain piled up on the crests of the elevations; while others have lodged on their sides or rolled down to their bases. Many of these blocks have a peculiar metallic or phonolithic sound when struck; the well-known "ringing stones" west of Bellary afford a good example. These black, bare, ridges of loose stones, standing out in relief against the light-coloured granite or gneiss rocks, add another striking feature to the landscape of the plutonic and hypogene tracts. They often cross the country in a thick network, particularly between Nundidroog and Bangopilly in Mysore. Fig. 4 is a side view of a dyke projecting from the granite.

Fig. 1.

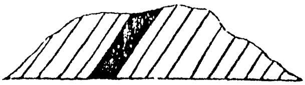


Fig. 2.

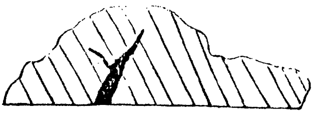


Fig. 3.

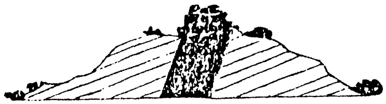
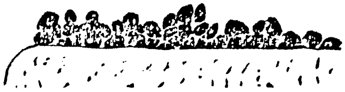
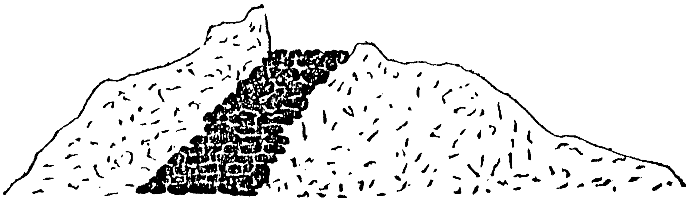


Fig. 4.



Sometimes the course of the dyke is distinctly observable at the distance of many miles by piles of such masses heaped on the mountains; and marking, with a well-defined line, the course of the dyke in the granite below, still compact and unbroken. Fig. 5 is a sketch of a large dyke near Bangopilly, ninety paces broad at the base, and seventy where it crosses the crest of the granite rock like a saddle.

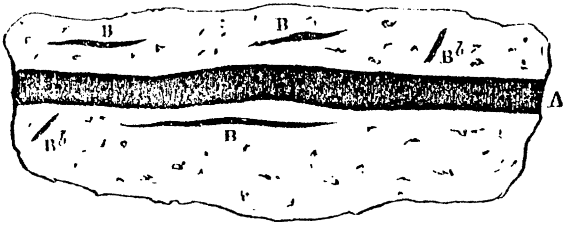
Fig. 5.



In many cases the protrusion of the basaltic greenstone above the general surface of the imbedding rock appears to have been occasioned by the weathering of the latter from its sides. The greenstone thus left unsupported and exposed to atmospheric action soon breaks up by the process of fissuring and concentric exfoliation. In a few instances it appears to have been forced in a semi-solid state beyond the lips of the rent in the rock without overlapping the rock; but none of these projecting dykes have remained in that solid continuous wall-like state in which we see the prominent dykes of Somma or the Val del Bove. Their height above the general level of the country rarely exceeds eighty feet.

Direction.—The direction of the main dykes appears generally to coincide with that of the elevation of the mountains; nearly N. and S. in the Western Ghauts; and on the table-land of India, where the spurs usually run E. and W. or W.N.W. and E.S.E., we find the dykes usually following a similar direction. Many exceptions will be found to this rule; and, indeed, if we trace any dyke, the general direction of which in a course of many miles may be N. and S., we shall find it to zig-zag and curve in various directions at different parts of its course. In some instances the dyke takes a rectilinear course across the gneiss-based plain, and may be traced for miles by the eye; in some parts forming a dark ridge of blocks, elevated only from 5 to 80 feet above the surface; at others passing through great bare rocks of granite 300 feet high; and, now and then, sinking below the surface, again to re-appear, as the eye follows the direction, in a similar rugged ridge.

Many dykes fine off as they approach their termination; others end abruptly, or re-appear at short intervals. Short parallel veins are sometimes observed at a little distance from, having no surface connexion with the main dyke; though they are doubtless off-shoots by lateral fissures from the great mass of fluid basalt below; to which these fissures form accessory vents. The following figure represents the surface of a granite rock in the vicinity of Hydrabad, penetrated by the trap dyke: A, B, B, B, B, B, are the lateral vents filled with basalt. Some of these detached vents B *b* are nearly at right angles with the main coulée.

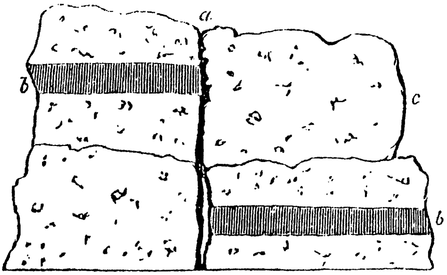


I have frequently traced these dykes to the distances of twelve and twenty miles.

Imbedded Rocks.—Fragments of granite and gneiss, both angular and of a lenticular form, are sometimes entangled and imbedded in the basalt; and have been mistaken for veins, or nests of these rocks. It is evident that, in many instances, the granite and hypogene rocks were solidified prior to the great eruptions of basalt that burst up from below into their seams and fissures, and that the molten fluid imbedded all loose fragments of rock, &c., lying in them. It is probable that many of the fissures themselves were caused, or enlarged, as seen in modern volcanos, by the expansion of the molten basalt and its gases from below, while struggling for a vent.

There is no gradual blending of the basalt with the granite: a distinct line of demarcation exists throughout; while the smooth vertical surfaces of the granite that walled the dykes, and formed the sides to the fissures, are usually as sharp and smooth as if cut by the chisel.

There is little doubt that, in a great many instances, the granite and hypogene rocks, into the fissures of which the basalt has been injected, have since its solidification suffered considerable disturbance and dislocation, as nothing is more common than to meet with faults in the course of the dykes, penetrating these rocks, often of great magnitude, the sharp edges of which show that the dyke must have been separated and the dislocation effected when the basalt was in a solid state.



a. Fault causing dislocation. *b, b.* Dyke. *c.* Granite.

Lithologic Character.—The lithologic structure of this rock is as protean as that of granite. In the centre of large dykes we usually find it crystalline and porphyritic; and nearer the edges, less crystalline and more compact; in fact, every gradation of amphibolitic and augitic rocks, from basalt to melaphyre, in the distance of a very few paces. Near the sides, in the compact varieties, may be seen needle-shaped crystals of augite glancing in confused arrangement here and there in the close texture of the basalt; while a little nearer to the centre the augite almost disappears, and is replaced by fine large crystals of hornblende, and sometimes a few scattered scales of mica a fact bearing out the experiments of Professor Rose. This celebrated practical chemist, in following up the experiments of Mitscherlitz of Berlin, who had succeeded in obtaining, artificially, perfect crystals of mica and augite from their component substances fused in the laboratory, melted a mass of hornblende in a furnace, and obtained invariably crystals of augite in cooling. Hence the inference of the identity of augite and hornblende: the latter only requiring a longer period of cooling for its crystallization.

Near the line of contact with gneiss, the basalt often loses its dark colour, and becomes of faint green, like some varieties of eurite, or serpentine, imbedding iron pyrites. This faint green eurite is also seen as a thin vitreous and vesicular enduit on its surface, like the scoriaceous lava found on the surface of the dykes of Etna. The cavities sometimes contain a yellowish-brown powder, which becomes magnetic before the blow-pipe, or small crystals of epidote: in one specimen I found prehnite. The surface of the compact basalt in the dykes is often scored by small fissures, which, as in the Vesuvian dykes, divide the rock into horizontal prisms, and run at right angles to the cooling surfaces.

All the darker varieties of basaltic greenstone melt into a black or dark-green coloured glass, or enamel; and affect the magnetic needle. They are composed of felspar, hornblende, and augite, in varying proportions, and occasionally hypersthene.

The minerals most common to these are, iron pyrites, garnets, epidote, and actinolite. These minerals distinguish them from the newer trap, which abounds in zeolites, calcedonies, and olivine. I have never observed any of these minerals in the basaltic greenstone; though olivine is said to occur in a solitary specimen of Dr. Voysey's, in the museum of the Geological Society: this specimen, it is possible, may have been mistaken for one from the newer trap; although it is stated to have been taken from a greenstone dyke passing through granite, near Guntoor, south of the Kistnah.

Mica, quartz, selenite, and calc spar rarely occur.

In the greenstone of a dyke in the Cuddapah sandstone, in the hills a little south of Chittywanrypilly, on the Gooty road, I found almond-shaped and oval cavities filled with reddish foliated crystals and a mineral resembling prehnite; but the haste with which I was marching prevented my examining these minerals at the time, and the specimens were unfortunately lost.

Structure.—The greenstone occasionally assumes the prismatic columnar forms of the newer basalts, or rather approaches to this structure, as in the vicinity of Chittywanrypilly, Kurnool, and other localities; thin layers of carbonate of lime often intervene between the joints, and between the concentric layers of the globular greenstone.

In many instances the basalt has a fissile structure, which, when intersected by joints, form prisms well adapted for building purposes, to which I saw them applied by the Hindús near Havrighi, on the north bank of the Kistnah. In some cases, under the hammer, it breaks into rhomboidal fragments, the joint planes of which are marked superficially with dark-brown or blue dendritic appearances on a pale yellow or brown ground. It is difficult to break these solids except in a direction parallel with the planes of cleavage, which are often indefinite and obscure at the joints. The last, as Professor Sedgwick has observed with regard to slate joints, are fissures often imperceptible in the greenstone, and placed at definite distances from each other; the masses of rock between them having, generally speaking, a tendency to cleave in a direction parallel to them.

Thus it is usually easy to distinguish the joint planes from those of cleavage. The disposition to oxidation of the metals contained in the rock, and their attraction to the surfaces of the joint planes, is doubtless owing to electric currents circulating in the pores of the rock.

Rocks altered by Dykes.—Granite and gneiss in contact with a dyke usually become compact, or tough, or friable; the felspar crystals lose their brightness and a portion of the water of crystallization, become opaque, and of porcelain hue; the mica is hardened and loses its easily fissile lamellar character. In gneiss I have frequently seen it replaced by minute crystals of tourmaline, epidote, and garnet, as near Chinrayapatam in Mysore. Limestone is converted into chert, or becomes siliceous; sandstone into quartz; and clay slate into basanite, and jasper.

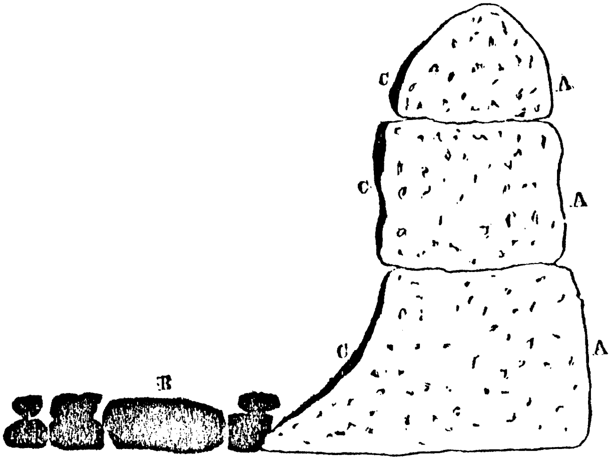
In districts most intersected by dykes a general tendency to crystalline and metallic development will be remarked, as well as an increase in the deposition of saline and calcareous matter, apparent in extensive layers of kunker, and efflorescences of the carbonate, muriate, and sulphate of soda. The fissures through which the springs charged with these minerals rise, were originally caused, perhaps, by the same disruptive forces that opened vents through the earth's crust to the molten basalt: and it is not improbable that these minerals and sulphates have their origin in causes connected with these ancient subterranean volcanic phenomena.

Frequently no alteration is to be traced in the rocks in contact with dykes; a circumstance readily accounted for when we reflect that the temperature of the injected rock is liable to great variation.

In certain localities, indeed, the basalt appears to have been reciprocally acted upon by the rock it has traversed. In the eastern ranges of the Ceded Districts, the basalt passing through the clay slate has frequently converted it into flinty slate; while the basalt itself, near the edges, has acquired a slaty structure, and become so much modified in mineral character as to be distinguished with difficulty from the altered clay slate in the vicinity.

The granite at the edge of a dyke running through the Peacock hills, at Bellary, in the Ceded Districts, affords a curious example of the effects of heat. At a few points on the edges the granite seems to have been fused, and carried on for a short distance (two or three inches) in filons with the stream of basalt. The mica and felspar have been melted and mixed together in a grey mass, and the quartz has assumed a smoky hue, or resinous yellow, resembling colophonite. Three or four inches from the dyke the granite begins to assume its usual appearance; but the felspar crystals are semi-opaque, like porcelain.

In the same locality is found, at the edge of a branch of this dyke, at the foot of a high rock of granite, a grey vesicular mass, imbedding angular bits of quartz. It is apparently granite in a more perfect state of fusion; the imbedded bits of quartz are probably from a nest or vein of quartz in the granite: externally the mass has a rough scoriaceous aspect, not unlike some trachytes, and more rarely a nodular or slag-like exterior.



A, A, A. Granite rocks, about fifteen feet high.
B. Basaltic dyke, weathering into globular and cuboidal masses.
C, C, C. Incrustations of basalt adherent to the sides of the dyke above its present level.

In some situations the dykes pass through walls of granite which rise above them on each side, like the precipitous banks of a river over the stream they flank; these walls have the appearance of having been filled with the fused basalt to a greater height than at present. A coating of basalt still adheres to the faces of many of the precipices, much above the present level of the dykes. Whether the basalt in the dyke has since shrunk down on cooling, or been removed by denudation, is doubtful. Fig. 1 is a sketch from a dyke in the granite near Bellary.

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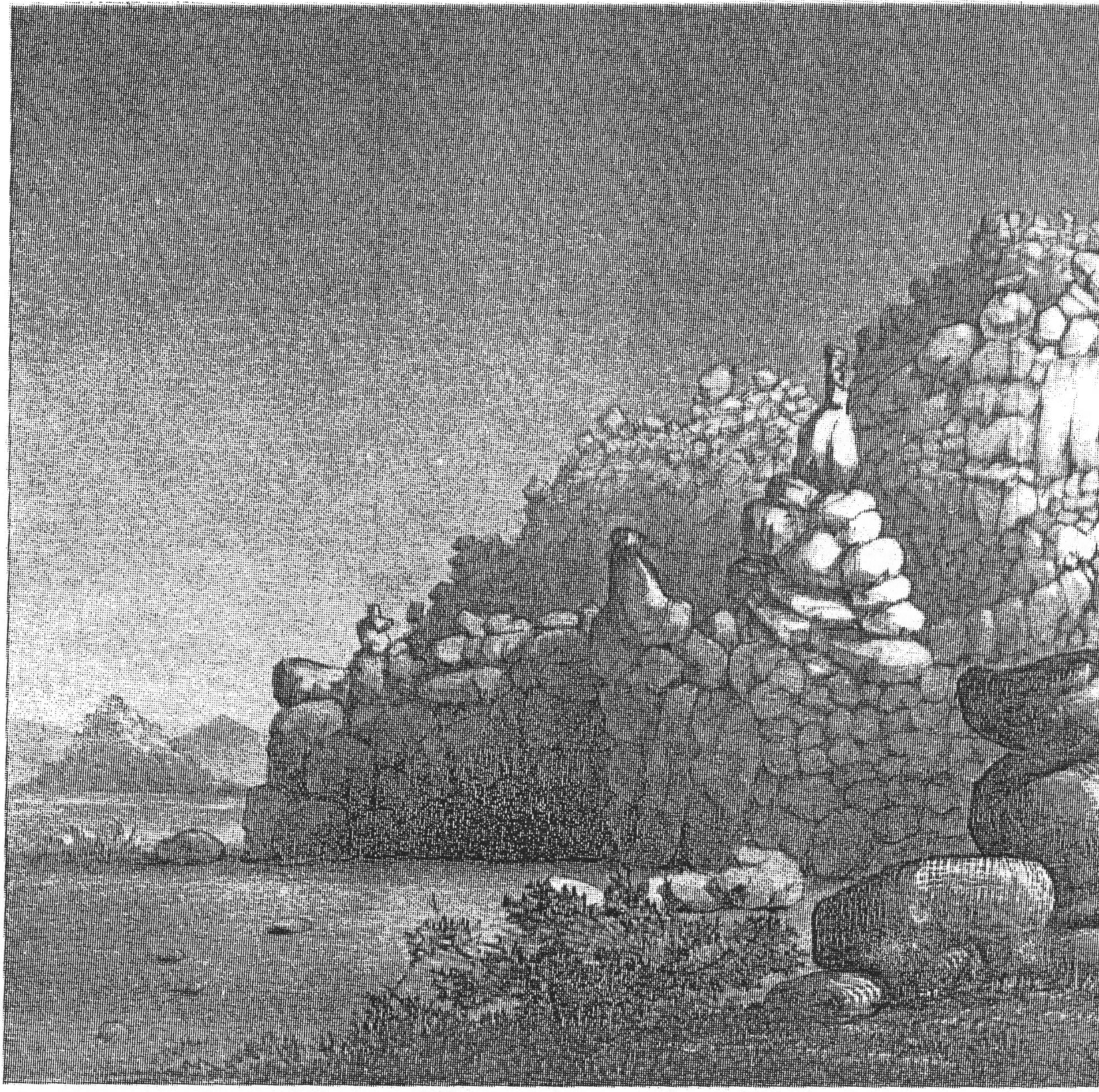
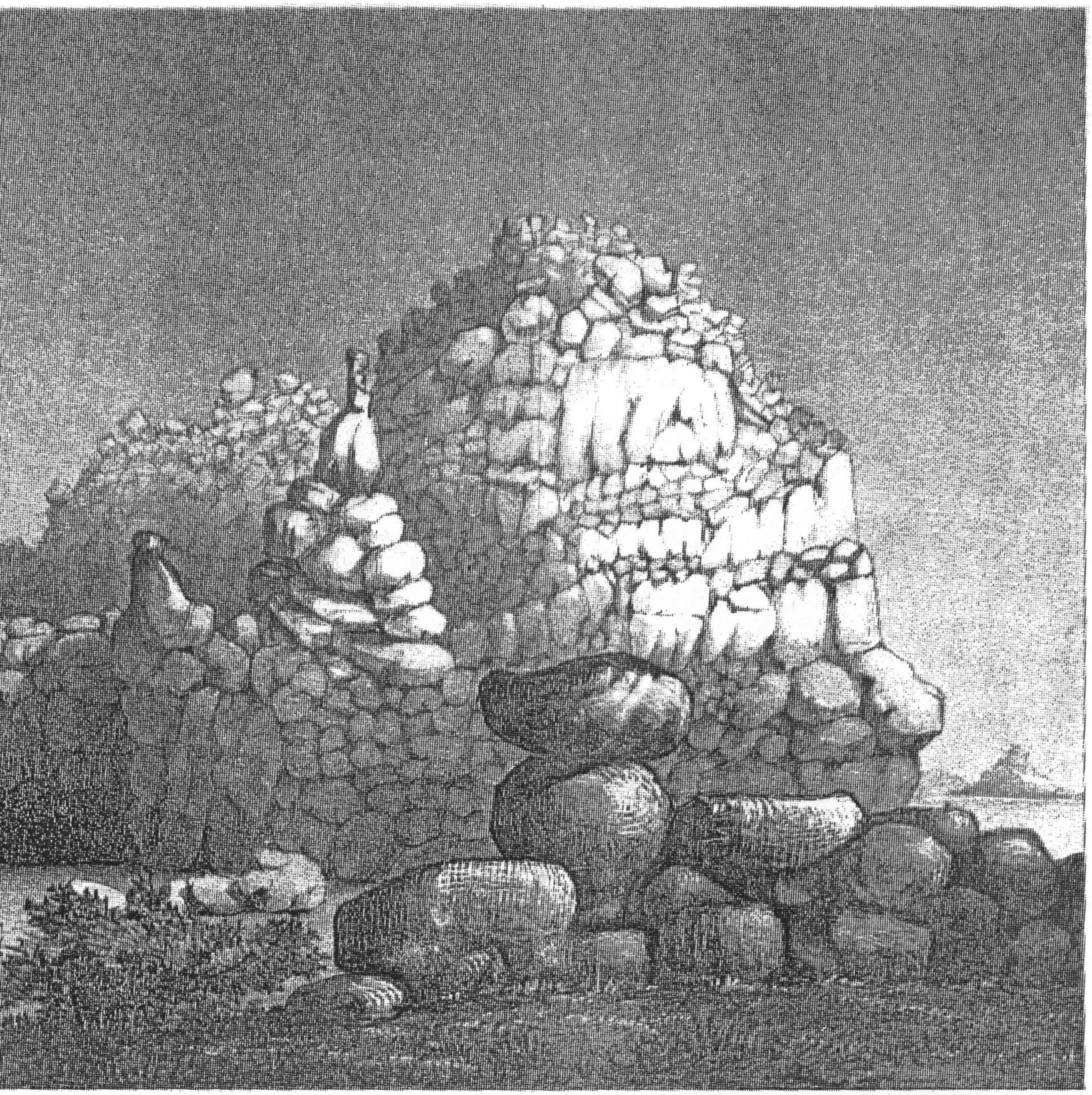


CONCENTRIC EXFOLIATION OF GRANITE FROM THE ROCKS CLOS



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EXFOLIATION OF GRANITE FROM THE ROCKS CLOSE TO BELLARY.